June 2, 1964 F. SPIEGEL 3,135,815

METHOD FOR THE REPRESENTATION OF THE MOVEMENT OF TWO BODIES BY MEANS OF ELECTRON BEAMS AND APPARATUS FOR CARRYING OUT THIS METHOD

Filed Sept. 1, 1960 3 Sheets-Sheet 1

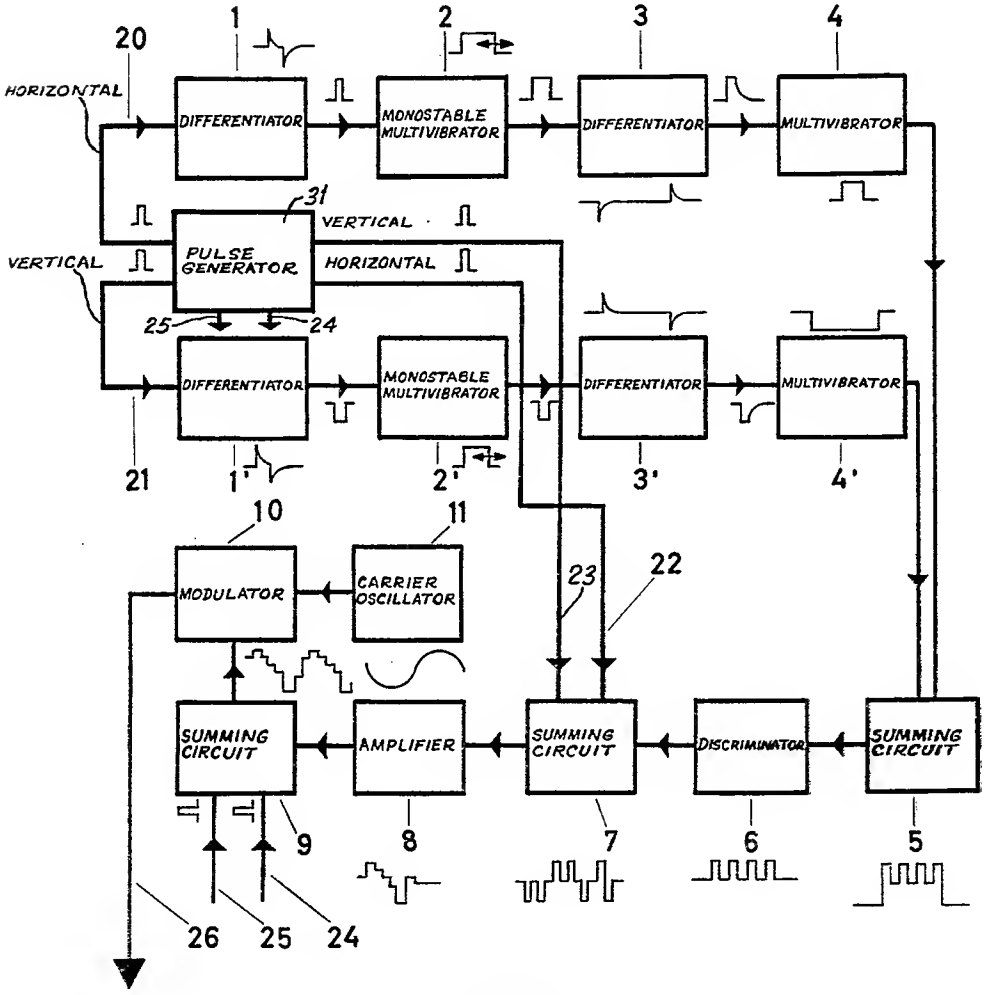

FIG.1

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Filed Sept. 1, 1960 3 Sheets-Sheet 2

FIG.2a

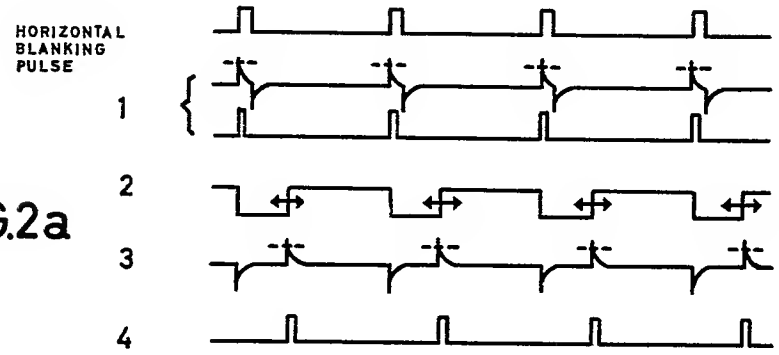


FIG.2b

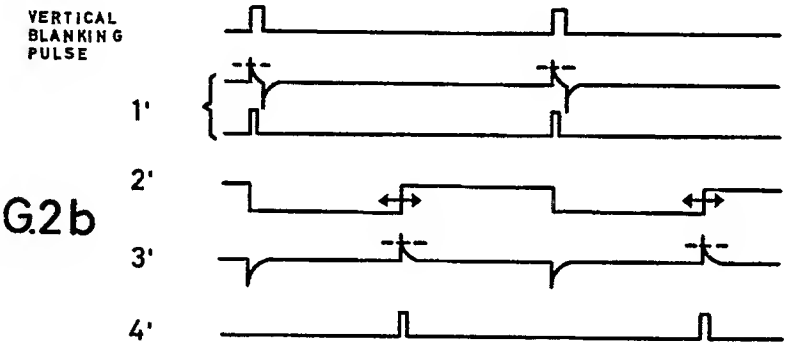
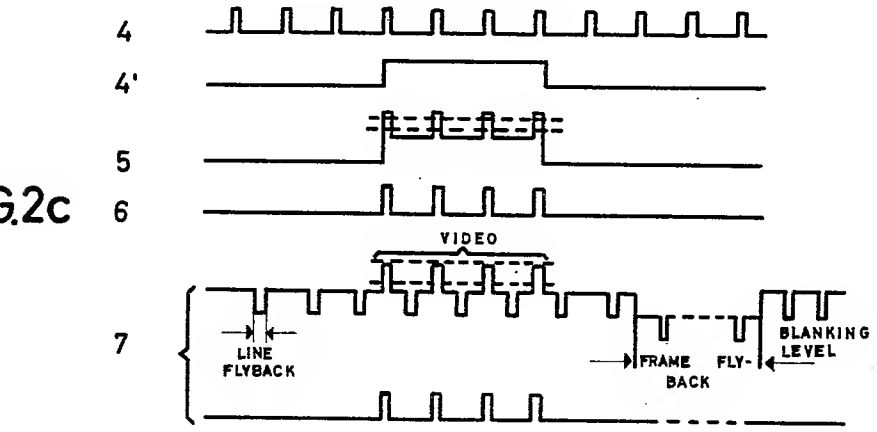


FIG.2c



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Filed Sept. 1, 1960 3 Sheets-Sheet 3

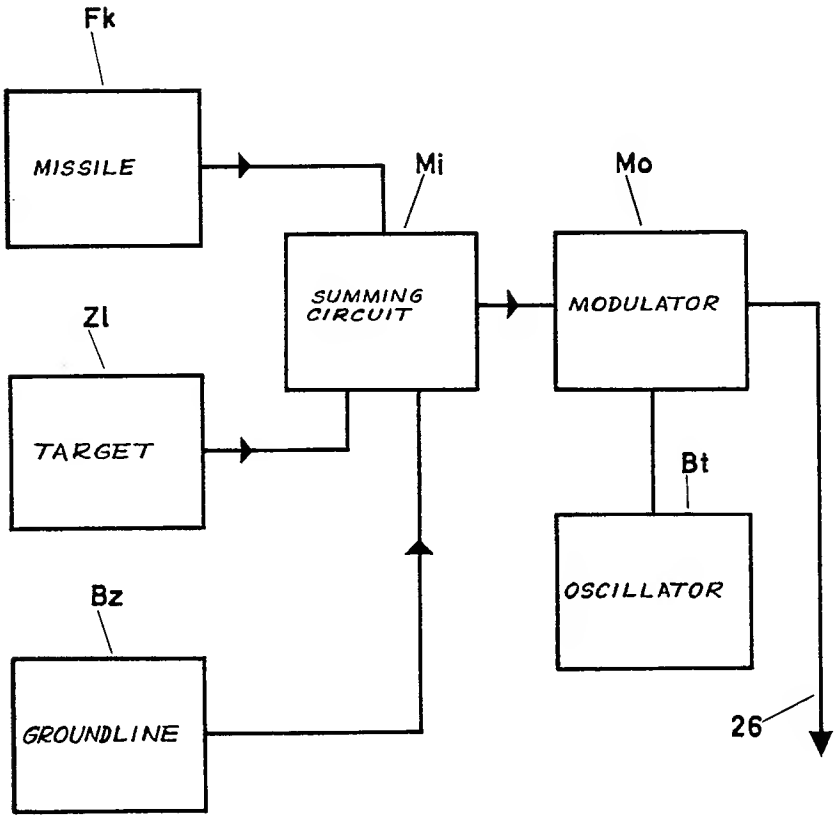

FIG.3

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METHOD FOR THE REPRESENTATION OF THE MOVEMENT OF TWO BODIES BY MEANS OF ELECTRON BEAMS AND APPARATUS FOR CARRYING OUT THIS METHOD

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6 Claims. (Cl. 35—10.4)

The invention relates to a method for representing the movement of two bodies, particularly a guided missile and a target to be hit by the missile by means of electron beams, and an apparatus for carrying out this method.

Apparatus of this type, generally referred to as simulators, produce simulated movement of a guided missile and its reactions to deflections and represent these in the form of a movable light speck. A three-dimensional effect is produced in such cases by a substantially perspective projection wherein a central beam is kept in alignment through the eyes of the persons guiding the missile and the target. The dimension depth thus appears as the flight period of the missile from its firing point to the target.

The purpose of the present invention is to simplify known simulators which usually consist of electronic computers and a cathode ray/oscillograph-like device, in such a way that TV signals representative of the missile and target to be simulated are produced which are adapted to be displaced in phase relationship relative to frame and line synchronization pulses generated by a pulse generator so that the resulting picture content will represent the momentary position of the missile and target to be simulated in a rectangular coordinate system on the screen of a picture tube.

The displacement of the picture contents corresponding to the missile and the target is effected separately, for example by hand and/or in accordance with a contemplated program so that the actual movement conditions in steering a guided missile onto a stationary or mobile target can be reproduced as accurately as possible.

The range of the target is simulated by an adjustable timer and as the latter runs out the movements of the missile and target are arrested so as to make possible a score control. The contacting of the missile with the target in the time period is indicated by a bright flash which is produced by gating of the Wehnelt cylinder of the picture tube.

The ground which the viewer visualizes as rising being simulated so as to avoid flights under the target while being responsive to flights over the target is represented in accordance with the present invention as an inserted grey line which approaches the missile appearing on the picture screen in a manner proportionate to the distance or rather to the consumed flight period.

Instead of the devices used heretofore, which generally consist of a unit for the missile to be simulated and a unit for the target to be simulated, and which are connected by synchronizing arrangements and, therefore require considerable space and are extremely expensive, there is now provided a pulse generator, which produces horizontal and vertical blanking pulses for a TV receiver. These blanking pulses are used in the production of the picture needed for the representation of the missile and target. Thus the desired picture is produced by a relatively simple and above all inexpensive apparatus. Moreover, it is possible to dispense with special recording devices since the present invention contemplates representing the movements of the simulated missile and target on a conventional TV receiver. It is also possible to

connect any desired number of TV receivers to the single pulse generator of the present invention, so that any number of persons can view the simulated steering operation.

According to the present invention it is also contemplated to blend a landscape image into the TV representation of the movement of the missile and target and thus reproduce a true-to-life image on the picture screen of a target moving over the terrain and a missile flying in the air space thereabove. It is also proposed to use instead of the direct visual tube a projection tube as the indicator tube, so as to project a picture unit onto a canvas screen and thus obtain in a very simple way so-called "shooting movies."

Other aspects and features of the invention will appear from the following description with reference to the accompanying drawings which diagrammatically represent an arrangement for carrying out the inventive system and wherein:

FIG. 1 shows a block diagram of an arrangement for producing a picture signal representing a missile or a target in accordance with the invention;

FIGS. 2*a*, 2*b* and 2*c* show pulse trains generated by the circuits in the arrangement of FIG. 1; and

FIG. 3 shows the basic circuit diagram of a complete arrangement for reproduction of the movement pattern of the missile and the target on the picture screen of a television tube.

The present invention makes use of a pulse generator of the type used in television systems to generate horizontal synchronization and blanking pulses and vertical synchronization and blanking pulses of the type used in ordinary television signals.

The picture signals representing the missile and target to be simulated are each produced in a circuit as shown for example in FIG. 1 for the picture signal of the missile. The horizontal blanking pulses derived from the pulse generator **31** are applied to line **20** and are amplified and differentiated in a differentiator **1**. The pulse train comprising these horizontal blanking pulses is illustrated in FIG. 2*a* along with several other waveforms generated in the circuit shown in FIG. 1. In FIG. 2*a* as well as in FIG. 2*b* and 2*c* the pulse trains are designated by the same reference numbers as the circuits which generate them and which are illustrated as blocks in FIG. 1. The time base is the same for all the pulse trains in any one of the FIGURES 2*a*, 2*b* and 2*c*, so that each FIGURE 2*a*, 2*b* and 2*c* illustrates the phase relationships of the waveforms depicted in that figure. By means of the positive pulse components in the pulse train output of the differentiator (see FIG. 2*a*), the oscillations of a monostable multivibrator **2** are controlled. As shown in FIG. 2*a*, the multivibrator **2** in response to the positive pulse components in the pulse train output of the differentiator **1** generates a square wave pulse train output at a frequency equal to that of the positive pulse components in the pulse train output of the differentiator **1** or in other words to the frequency of the horizontal blanking pulses. The square wave pulses in the output of the multivibrator **2** are negative going and have the leading edges coinciding with the positive pulse components in the pulse train produced by the differentiator **1**. The negative going square wave pulses in the pulse train output of the multivibrator **2** are selectively variable in length and a change in the pulse lengths of these pulses is effected by changing the discharge constants in the multivibrator **2** by varying a variable resistor.

The pulse train output of the multivibrator **2** is differentiated in a differentiator **3**, thus providing a positive pulse in the output of the differentiator **3** coinciding with the trailing edge of each negative going square wave

pulse in the output of the multivibrator 2, as shown in FIG. 2a. The output of the differentiator 3 is applied to a multivibrator 4 and the positive pulse components in the output of the differentiator 3 control the oscillation of the multivibrator 4, which in response to the positive pulse components in the output of the differentiator 3 produces positive going rectangular pulses, which coincide with the positive pulse components in the output of the differentiator 3, as shown in FIG. 2a. The time of occurrence of the rectangular pulses in the output of the multivibrator 4 in relation to the horizontal synchronization and blanking pulses determine the horizontal position of the visual representation of the missile on the television screen. The width of the pulses generated by the multivibrator 4 determine the width of the visual representation of the missile on the television screen.

The vertical position of the visual representation of the missile is determined in a similar manner from the vertical blanking pulses produced by the pulse generator. The vertical blanking pulses produced by the pulse generator are applied over a line 21 to a differentiator 1', in which the vertical blanking pulses are differentiated and amplified. The pulse train of the vertical blanking pulses is illustrated in FIG. 2b. The output of the differentiator 1' (see FIG. 2b) is applied to a monostable multivibrator 2'. The multivibrator 2' is controlled in response to the positive pulse components in the output pulse train from the differentiator 1', and in response thereto generates a square wave pulse train output, as shown in FIG. 2b. The square wave pulses generated by the multivibrator 2' are negative going and their leading edges coincide with the positive pulse components in the output of the differentiator 1'. The length of the negative going square wave pulses are variable and the change in pulse length of these negative going square wave pulses is effected by changing the discharge constants in the multivibrator 2' by varying a variable resistor. The square wave negative going pulse train output of the multivibrator 2' is differentiated by a differentiator 3'. The positive value pulse components in the resulting pulse train output of the differentiator 3' will coincide with the trailing edges of the negative going square wave pulses generated by the multivibrator 2', as shown in FIG. 2b. The pulse train output of the differentiator 3' is applied to a multivibrator 4', which, in response to the positive pulse components in the output pulse train of the differentiator 3', generates a pulse train of positive going rectangular pulses, each of which coincides with a positive pulse component in the pulse train output of the differentiator 3', as shown in FIG. 2b. The time of occurrence of the rectangular pulses generated by the multivibrator 4' in relation to the vertical blanking and synchronization pulses generated by the pulse generator determines the vertical position of the visual representation of the missile on the television screen. The vertical dimension of the visual representation of the missile is determined by the width of the rectangular pulse generated by the multivibrator 4'.

From the pulses generated by the multivibrators 4 and 4' it is possible to obtain in a simple way a visual representation of the position of the missile on rectangular coordinates on a television screen. This is so because on the picture screen of a television receiver the pulses, in the output of the multivibrator 4, occurring at the line frequency, define a vertical coordinate, and the pulses, in the output of the multivibrator 4', occurring at the frame frequency, will define a horizontal coordinate. Although in FIGS. 2a and 2b the rectangular pulses in the outputs of the multivibrators 4 and 4' appear as though they have a similar frequency, it will be realized that the pulses in the output of the multivibrator 4 occur at the frequency of the horizontal blanking pulses whereas the rectangular pulses in the output of the multivibrator 4' occur at the much lower frequency of the vertical blanking pulses. Similarly the rectangular pulses generated by the multivibrator 4' are much wider than the rectangular pulses generated by the multivibrator 4, as better illustrated in FIG. 2c. The pulse trains generated by the multivibrators 4 and 4' are additively mixed in a summing circuit 5, and the pulses in the resulting output of the summing circuit 5 will have a greater magnitude at the times when the pulses from the multivibrator 4 coincide with the pulses from the multivibrator 4', as shown in FIG. 2c. The pulses of greater amplitude in the output of the summing circuit 5 are passed in an amplitude discriminator 6. The resulting output from the amplitude discriminator 6 will be a video signal as shown in FIG. 2c. Horizontal and vertical blanking pulses are added to the video signal in a summing circuit 7 so that the flyback of the electron beam will be blanked in the scanning operation in the TV receiver, on the screen of which the visual representation is to be produced. The summing circuit 7 has applied thereto from the pulse generator the horizontal blanking pulses over line 22 and the vertical blanking pulses over line 23. The resultant signal containing appropriately blanked intervals is amplified in an amplifier 8 and given the desired polarity, i.e. a positive or negative picture signal, depending upon whether the visual indication appearing on the picture screen is to be black or white. The picture signal is combined in a summing circuit 9 with the synchronizing pulses over lines 24, 25 from the pulse generator. The horizontal synchronizing pulses are supplied through line 24 to the summing circuit 9 and the vertical synchronization pulses through line 25. If necessary, further picture signals can be added, for example those of a landscape image. The resulting mixture is modulated upon a carrier in a moderator 10, said carrier being taken from an oscillator 11 and having a frequency corresponding to a standard television channel. The modulated high frequency is then supplied through line 26 to a conventional television receiver.

The displacement of the light speck produced in this manner on the picture screen of the television tube is effected by means of the variable resistances within the monostable multivibrators 2 and 2'. These resistances are varied by means of a control column which is supported on a universal joint and is connected to a so-called steering device which is provided with at least the starter button for initiating a steering operation.

The production of the target picture on the picture screen of the television screen necessitates, as already mentioned, the provision of a further circuit arrangement like that shown in FIG. 1. The working together of both circuit arrangements is shown basically in FIG. 3, wherein the circuits 1–4, 1'–4' and 5–8 for the reproduction of the missile and the target are combined, for the sake of expediency, in boxes *Fk* and *Zl* respectively. The pulses representing the missile to be simulated which are produced in circuits 1–4, 1'–4' and 5–8, as well as the pulses representing the target to be simulated which are produced in the same manner with identical circuitry, are combined in a summing circuit *Mi* with the synchronizing pulses derived from the pulse generator, not shown, and are supplied to a modulator *Mo* where they are modulated upon a television channel carrier taken from oscillator *Bt*. The summing circuit *Mi* has also supplied to it the signal for producing the inserted grey ground line from the circuit *Bz*. The ground line represents the position of the ground relative to the missile. The ground line signal is varied so that the ground line approaches the missile at a rate proportionate to the running of the flight period and will meet the missile when the flight period runs out.

The pulse mixture taken from the modulator *Mo* is then supplied through line 26 to a conventional television receiver. On the picture screen of the television receiver there will appear the missile-light speck, which can be displaced by means of a control column, and the target-light speck, which can also be displaced by means of a control column arranged in an actuating device. How-

ever, the target, instead of being moved by hand can equally well be moved over the picture screen with the aid of a suitable circuit in accordance with a selected program.

In order to achieve a representation rich in contrasts of the missile and the target, the latter may be reproduced for example as a black rectangle of a magnitude dependent upon the adjustable target distance. The control means needed for this are also arranged in the actuating device. The control of the target size may also be effected in such a way that it will change during a steering operation in proportion to the distance. The missile is preferably represented as a small bright rectangle which is not much larger than a picture point and which does not change during the steering operation.

The ground line, which is controlled by an automatic ground line signal generator, prevents the missile from flying under the target. If the missile is steered onto the ground line before the flight period runs out, a coincidence circuit, also not shown, will be activated for the purpose of creating a flashing of the missile which takes place upon gating of the Wehnelt cylinder of the picture tube. The coincidence circuit will also be acted upon by the timer that controls the flight period so that after the time corresponding to the range of missile and target the elapsing of the time period will also be indicated by a flashing of the missile. If the person operating the steering device is able to achieve coincidence of the missile and target before the selected flight period runs out in accordance to the distance between the target and firing point, the missile is flashed by the activation of the coincidence circuit and this makes it possible to give accurate score indications.

A landscape picture can also be blended, through circuit Bz, into the television receiver as the latter is indicating the movement pattern, so that a true-to-life image of a target moving through the terrain and a missile flying through the air space thereabove can be shown.

It is possible also to connect a television receiver with a projection tube to line 26 so that the picture content can be projected on a canvas.

The circuits described above can be suitably constructed in the form of plug-in units and located in a common frame-like housing which may have the dimensions of an average conventional television receiver set.

What is claimed:

1. An apparatus for generating television signals for a simulation apparatus comprising a pulse generator adapted to generate horizontal synchronization and blanking pulses and vertical synchronization and blanking pulses, a missile horizontal position signal means responsive to the output of said pulse generator to generate a train of pulses occurring at a frequency equal to the frequency of occurrence of said horizontal synchronization and blanking pulses and selectively variable in phase relative to said horizontal synchronization aud blanking pulses, a missile vertical position signal means responsive to the output of said pulse generator to generate a train of pulses occurring at a frequency equal to the frequency of occurrence of said vertical synchronization and blanking pulses and selectively variable in phase relative to said vertical synchronization and blanking pulses, a first summing circuit connected to additively combine the pulse trains generated by said missile horizontal position signal means and said missile vertical position signal means, a first amplitude discriminator connected to pass all the pulses in the output of said first summing circuit over a predetermined amplitude, a target horizontal position signal means responsive to the output of said pulse generator to generate a train of pulses occurring at a frequency equal to the frequency of occurrence of said horizontal synchronization and blanking pulses and selectively variable in phase relative to said horizontal synchronization and blanking pulses, a target vertical position signal means responsive to the output of said pulse generator to generate a train of pulses occurring at a frequency equal to the frequency of occurrence of said vertical synchronization and blanking pulses and selectively variable in phase relative to said vertical synchronization and blanking pulses, a second summing circuit connected to additively combine the pulse trains generated by said target horizontal position signal means and said target vertical position signal means, a second amplitude discriminator connected to pass the pulses in the output of said second summing circuit over a predetermined amplitude, and means including a third summing circuit connected to additively combine the outputs of said first and second amplitude discriminators.

2. A method for generating television signals for simulating the position of a target and a missile on rectangular coordinates in a television display comprising the steps of generating television horizontal synchronization and blanking pulses and vertical synchronization and blanking pulses, generating a first train of pulses occurring at a frequency equal to the frequency of occurrence of said horizontal synchronization and blanking pulses, generating a second train of pulses occurring at a frequency equal to the frequency of occurrence of said vertical synchronization and blanking pulses, producing a third train of pulses whenever the pulses of said first and second trains coincide, varying the phase of said first train of pulses in relation to said horizontal synchronization and blanking pulses in accordance with the simulated horizontal position of said missile, varying the phase of said second train of pulses relative to said vertical synchronization and blanking pulses in accordance with the simulated vertical position of said missile, generating a fourth train of pulses occurring at a frequency equal to the frequency of occurrence of said horizontal synchronization and blanking pulses, generating a fifth train of pulses occurring at a frequency equal to the frequency of occurrence of said vertical synchronization and blanking pulses, generating a sixth train of pulses occurring whenever the pulses of said fourth and fifth trains coincide, varying the phase of said fourth train of pulses in relation to said horizontal synchronization and blanking pulses in accordance with the simulated horizontal position of said target, varying the phase of said fifth train of pulses relative to said vertical synchronization and blanking pulses in accordance with the simulated vertical position of said target, and additively combining said third train of pulses with said sixth train of pulses.

3. An apparatus for generating television signals for simulating the position of a first and of a second body on rectangular coordinates in a television display comprising a pulse generator adapted to generate first horizontal blanking and synchronizing pulses and second vertical blanking and synchronizing pulses for simulating the position of said first body and third horizontal blanking and synchronizing pulses and fourth vertical blanking and synchronizing pulses for simulating the position of said second body, a first means responsive to the output of said pulse generator to generate a first train of pulses occurring at a frequency equal to the frequency of occurrence of said first horizontal blanking pulses and selectively variable in phase relative to said first horizontal blanking pulses, a second means responsive to the output of said pulse generator to generate a second train of pulses occurring at a frequency equal to the frequency of occurrence of said second vertical blanking pulses and selectively variable in phase relative to said second vertical blanking pulses, a first summing circuit connected to additively combine the pulse trains generated by said first and second means, a third means responsive to the output of said pulse generator to generate a third train of pulses occurring at a frequency equal to the frequency of occurrence of said third horizontal blanking pulses and selectively variable in phase relative to said third horizontal blanking pulses, a fourth means responsive to the output of said pulse generator to generate a fourth train of

pulses occurring at a frequency equal to the frequency of occurrence of said fourth vertical blanking pulses and selectively variable in phase relative to said fourth vertical blanking pulses, a second summing circuit connected to additively combine the pulse trains generated by said third and fourth means, and a third summing circuit connected to additively combine the pulse trains derived from said first and second summing circuits.

4. An apparatus for generating television signals for a simulation apparatus comprising a pulse generator adapted to generate horizontal blanking and synchronizing and vertical blanking and synchronizing missile and target pulses, a first cascade of circuit means to generate a train of missile horizontal position pulses, said first cascade having an input connected to the output of the horizontal blanking missile pulses of said pulse generator, and having an output, a second cascade of circuit means to generate a train of missile vertical position pulses, said second cascade having an input connected to the output of the vertical blanking missile pulses of said pulse generator, and having an output, a third cascade of circuit means to generate a train of target horizontal position pulses, said third cascade having an input connected to the output of said horizontal blanking target pulses of said pulse generator, and having an output, a fourth cascade of circuit means to generate a train of target vertical position pulses, said fourth cascade having an input connected to the output of said vertical blanking target pulses of said pulse generator, and having an output, each cascade comprising a differentiator connected to differentiate said blanking pulses derived from said pulse generator, a multi-vibrator connected to the output of said differentiator and operated in response to the output of said differentiator to generate a train of square wave pulses of selectively variable width and having their leading edges coinciding with the pulse components of one polarity in the output of said differentiator, and circuit means connected to the output of said multivibrator and operated in response to the output of said multivibrator, a first summing circuit connected to additively combine the outputs of said first and second cascade, a first amplitude discriminator connected to pass the pulses over a predetermined amplitude in the output of said first summing circuit, a second summing circuit connected to additively combine the outputs of said third and fourth cascade, a second amplitude discriminator connected to pass the pulses over a predetermined amplitude in the output of said second summing circuit and means including a third summing circuit connected to additively combine the outputs of said first and second amplitude discriminators.

5. An apparatus according to claim 4, wherein said means including a third summing circuit comprises a fourth summing circuit provided to additively combine the output of said first amplitude discriminator with said missile horizontal and vertical synchronizing pulses, and a fifth summing circuit provided to additively combine the output of said second amplitude discriminator with said target horizontal and vertical synchronizing pulses.

6. An apparatus according to claim 4, wherein an oscillator is provided to generate a television channel carrier, and a modulator is connected to modulate said carrier with the output of said third summing circuit.

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